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FORTY-SECOND ANNUAL REPORT
FOR THE CALENDAR YEAR 1952

- Northern -
Rocky Mountain
Forest & Range
Experiment Station
Missoula Montana

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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FORTY-SECOND ANNUAL REPORT

INTRODUCTION

While the importance of forest research is now widely recognized, probably no other group realizes the needs for research better than those of us actually engaged in investigative work. After all, it is our job to determine where problems exist, to evaluate them, to plan investigations, and to arrive at sound conclusions. We try to be critical of forest and range land management so that we can find better and cheaper ways of getting jobs done. Intelligent appraisal of the opportunities for research to contribute something useful is an essential first step in getting an investigative program properly in gear with needs.

However, no matter how soundly our research group may evaluate the needs and plan and execute a study program, we inevitably feel staggered by the immensity of the job that confronts us. For example, in the Northern Rocky Mountain region we see our forest inventories lagging behind current demands for information. Important economic studies on which sound development of the region will rest, go undone. Some range lands continue to deteriorate under faulty management while we struggle with range managers' questions on reseeding deteriorated areas or controlling undesirable or poisonous vegetation. We have unanswered questions on the proper stocking of range lands and on the best dates for opening and closing the grazing season. We see opportunities to reduce costs and promote greater efficiency in forest fire control by research in fire behavior, fire prevention, and fire suppression methods. We know that research can assist in engineering more efficient designs for fire control systems. Refinements are needed in fire danger rating systems, on which the activities of whole fire organizations and the expenditure of thousands of dollars are based every year. We feel we might conquer some tree diseases or increase growth substantially if we could only carry out needed genetics studies. Large expenditures of stand improvement money would be on a sounder basis if answers to numerous silvicultural questions were available. Together with the land managers we fear that lack of information on soil and water may lead to mismanagement of important water-producing lands. We see 600,000 cords of unused timber left in the woods after logging, and 500,000 tons of sawdust produced annually in the region. What uses could be made of this material to lessen pressures on scarcer high-quality timber? We know that sound management back in the woods depends upon better know-how in the field of utilization. And so it goes, on and on, almost without end.

But, fortunately, we have at least a partial solution to what would otherwise be a tremendous job. That answer is "Cooperation." Most researchers realize that the pooling of efforts under a coordinated plan is necessary if progress is to be most rapid and if needless duplication is to be avoided. Forest and range managers, industrial groups, and colleges, too, feel the need for supporting research and making it a truly cooperative activity.

The opportunities to gain through cooperative research have been so great that this approach has been emphasized during the past year. Progress has been substantial, though perhaps modest in relation to what can be done. The outlook is sufficiently promising that this annual report features the cooperative attack on forest and range research in the Northern Rocky Mountain region.

STATUS OF COOPERATIVE RESEARCH IN THE NORTHERN ROCKY MOUNTAIN REGION

Of course, cooperation between the Northern Rocky Mountain Station and other research agencies is not new. Over the years we have had formal working agreements with research institutions, other federal bureaus, and a few individuals. The current list of active cooperators is quite impressive, as the following tabulation indicates:

Colleges and universities	4
State agricultural experiment stations	2
Farmers, ranchers, stockmen	11
Railroads	3
Forest products industries	10
Industrial associations	2
Private research foundations and laboratories	2
States	2
Municipal and county governments	3
Foreign country	1
Miscellaneous organizations and industries	3
Other federal bureaus and departments	11
Total	54

Some of the agencies included in the above list are cooperating in several fields of work or on more than one study. For example, we have close working relations with the University of Idaho on studies of white pine pole blight, blister rust, logging slash disposal, and the development of rain and snow gages. One industrial concern actively cooperates on transmission pole drying and service studies, investigations of regeneration, seed supply, deer damage to reproduction, and rodent problems.

HOW COOPERATION WORKS

There is nothing mysterious about cooperation in research. It merely requires a common desire to work together to the completion of a job and mutual trust in carrying out plans. It pays off because each cooperator can contribute special skills or facilities which the others do not have. An illustration or two will make clear how this sort of cooperation works.

During the year plans were completed and a study program started on problems associated with disposal of logging slash. Slash disposal is a

million-dollar activity in the Northern Rocky Mountain region and industry, the States, and the federal government are all concerned with the progress being made in keeping up with the job. The University of Idaho took the lead, backed by a lumber company, in some phases of the study. The station, because of natural advantages in facilities and personnel, agreed to take the initiative in other phases. Finally, on a planned basis, here is what we had on this one study during the summer of 1952.

1. A university supplying technical personnel, laboratory facilities and equipment, and some supervision.

2. An industry financing a graduate student to work on one aspect of the problem.

3. National Forest Administration supplying technical guidance, 82 mandays of smokejumper labor, and mechanical equipment needed in the study.

4. A state forester supplying a 10-man slash crew for installation of field experiments on an experimental forest.

5. A neighboring federal experiment station lending specialist help in field work and financial assistance for special measurements.

6. The Northern Rocky Mountain Station providing field facilities, equipment, transportation, technical manpower, and supervision.

In this project there was a substantial exchange of personnel on various phases of the job. Equipment and facilities were pooled to make them most useful. A sum of money was advanced by one agency where it made possible an especially greater output by another.

Investigations of the pole blight disease, of several years' standing, illustrate how another cooperative research project functions. A "steering committee" composed of representatives of the University of Idaho, Division of Forest Pathology, Division of Forest Insect Investigations, Division of Blister Rust Control, Canadian Laboratory of Forest Biology, National Forest Administration, and the Northern Rocky Mountain Station meet periodically to review accomplishments and develop plans. The actual field of work is more or less divided by mutual agreement. One agency is making a pole blight survey to determine the extent and location of affected areas. Another is pioneering in physiological studies using newer radioactive isotopes in order to learn more about translocation and nutritional conditions of unhealthy trees. Others are working out the symptoms of pole blight, studying various suspicious fungi, and checking on the spread of the disorder. The station is testing eradication as a possible control method. Quarterly reports, to which all agencies contribute, help keep cooperative efforts in gear.

MAJOR PROBLEMS AND A COOPERATIVE APPROACH

Any research worker could compile a huge list of unsolved problems that justify attention if forest and range land management is to be on the soundest basis. However, certain major problems do stand out. If we are able to make reasonable progress in solving these, full use of the forest resource can be achieved on a stable and permanent basis. Cooperative research by all agencies is now playing, and will continue to play, an important role in getting along with the job. Some of the most important research jobs are discussed briefly in this section, as we at the Northern Rocky Mountain Station see them.

Water Resource Management

Many of the things we do in forest and range management undoubtedly have an important effect on the soil and water resource. We are becoming more and more committed to drastic silvicultural practices in the Northern Rocky Mountain region where we find it difficult otherwise to regenerate the choicest timber species. But how is the water resource affected by such measures as bulldozing out unwanted vegetation, machine piling of slash, heavy broadcast burning to control Ribes or to reduce the fire hazard, and the exposure of soil on substantial clear cut blocks? What effect does clear cutting have on snow accumulation and melt, especially in the drier regions where irrigation water supply is so important? Does the construction of 8 to 10 miles of sidehill jammer logging roads per square mile influence water movement to the detriment of future site productivity? How do our current range practices, particularly on heavy soils, affect water supply?

Unfortunately, the station is not making satisfactory progress on this major problem. During the year a cooperative project with the Corps of Engineers, U. S. Army, was begun. Infiltration, as related to soil type, vegetative cover, and land treatment, is being investigated and is providing some basic information on the movement of water into and through forest and range soils. Cooperative snow studies with the Corps were discontinued during 1952 due to reduced finances. The University of Idaho has been studying the effect of fire on soil, an important phase of the overall problem. To the extent possible, the station is obtaining general information on soil and water in relation to timber cutting experiments but on a very limited scale. One of the big jobs ahead is to determine how faster progress can be made in this field and how joint effort will speed us to the answers to questions like those above.

Forest Tree Improvement

Forest trees are one of the few crops in the United States that have not been improved significantly over wild natural stock through the science of genetics. Production of fruit, cereals, meat, and the fibre raised on farms has been multiplied manyfold by careful selection and breeding. There is no reason why the same exciting future cannot be realized for forests as for peaches, wheat, tobacco, or beef.

The Northern Rocky Mountain region is beset at the present time with insect and disease problems. More intensive management will help solve some of these difficulties. But in the long run, a large part of the answer is most likely to come through the selection and development of resistant races of trees. Take the progress in the development of a blister rust resistant white pine, for example. In less than three years, pitifully small efforts have given us encouragement well beyond our most optimistic hopes. Cooperation has played a major role in this study. The Office of Blister Rust Control, Division of Forest Pathology, a local university, National Forest administrators, and the California and the Northern Rocky Mountain Stations have pooled their efforts to get a project under way. None of these organizations could have carried even part of the program as effectively all alone. The results of this work, described later, give encouragement to cooperative research.

The opportunities for increased growth, higher quality, bountiful seed production, and other desirable characteristics in our important tree species are waiting to be realized. An expanded investigative program should be started now. Universities can boost this program with study of fundamental genetics. Pathologists should learn how disease resistance is transmitted. All foresters can speed up the selection of superior trees by learning how to recognize superiority.

Productivity of Range Lands

The determination of the potential productivity of plains and mountain ranges after three quarters of a century of use by domestic livestock and how to manage those ranges for high sustained production are problems of considerable magnitude and importance. Just about everything we do on the ranges should be governed by knowledge of how much palatable herbage the soil can produce. Is the present rate of stocking and the grazing period commensurate with productivity or does the grazing requirement of livestock on an area exceed it? Is a current production of 500 pounds of forage on a given acre acceptable or could the area produce more? Increases or decreases in stocking should be based on such information. Whether an investment in reseeding or in the control of undesirable plants will pay, depends upon how much increased forage production the site will support and how critical a need exists for increased production.

Much of the information needed to get on top of this problem lies in better knowledge of soil, water, and plant relationships. We need to determine soil characteristics and learn to interpret them in terms of plant growth. Here again, we need the cooperation of universities with their soil specialists, and other federal bureaus equipped to work on the problem.

Utilization of Wood Waste

What can be done to make profitable the utilization of surplus materials now available throughout the region, both in the woods and concentrated at manufacturing plants? Answer to this question will go a

long way toward relieving pressure on scarce, high quality species and will permit more intensive management in the forest.

But to realize more complete utilization we must attain greater technological skill. We know how to chip and pulp slabs, make domestic fuel out of mill waste, make wood molasses, turn out hardboard, and do a variety of other things with available residues. Many of the known processes are costly or not well adapted to small sized manufacturing units. But every time a new or cheaper method of making a synthetic board is discovered, for example, it means we are one step closer to fuller utilization and greater profits all the way back to the woods.

Industrial research groups and universities have an important part to contribute in solving wood waste problems. The Northern Rocky Mountain Station does not engage directly in utilization research but it does have a responsibility to assist the Forest Products Laboratory and other local research agencies formulate the research programs in this field. As with other studies, cooperative research can move us along faster than individual effort.

Fundamental Fire Research

Progress in fire prevention and control has been outstanding in the Northern Rocky Mountain region in the past 20 to 30 years, and we in research are proud of the contributions we have been able to make. However, foresters still have major problems confronting them. Improvements in transportation facilities, use of aircraft, increased logging, higher values at stake, and greater accessibility have affected fire control activities in one way or another.

Significant progress has been made and will continue to be made through applied research and limited study of isolated phases of the overall fire control problem. We feel the time has come, however, when the greatest need is for fundamental research into some of the most basic elements of fire protection. An understanding of inflammability and how it is related to fuel condition and arrangement would go a long way toward solving the logging slash problem. We see a need for a more thorough understanding of the fundamentals of fire behavior--a knowledge of how the factors that influence the rate of spread and intensity of a fire are related. If the physics and chemistry of combustion were properly understood, we would be in a better position to prescribe ahead of time just what manpower and equipment was needed for each burning condition, what safety precautions were necessary for the welfare of personnel, and what suppression tactics were most practical under each set of conditions.

Lightning fires have heretofore been more or less accepted as unpreventable--as acts of God. Now, we are not so sure but that man can modify or exercise some control over the forces that produce lightning. Certainly we need investigations into the fundamentals of lightning cloud formation and experiments in cloud dissipation.

Cooperation with various agencies is already under way in fire research. The approach being used in the logging slash disposal study has been described. In the field of fire behavior there is an opportunity for specialists in the universities to take a prominent part in physical and chemical studies relating combustion to fuel volume, arrangement, physical condition, environment, and similar factors. We have already begun a cooperative project with a privately endowed research foundation, national forest administration, and the U. S. Weather Bureau on studies of lightning prevention. The special skills of all groups brought to bear properly on this difficult problem may produce results of tremendous importance to regions having thousands of lightning fires each year.

Public Forests in our Regional Economy

About 45 percent of the forest and range land in the region is publicly owned. For the most part, this land is being managed and developed to make the greatest contribution to the welfare and enjoyment of the people. Managing these forests so that they contribute most to community growth and stability is a big task, especially so in this region where the development and use of forests is being rapidly expanded. Public forestry must be dynamic and be based on a constant appraisal of new situations and their bearing on local and national needs. That is why public foresters are continually seeking up-to-date answers to such questions as these: Is the management of public timber land integrated as well as it could be with the use of timber in private ownership? How much timber industry will public forests support? How can the range lands we manage fit better into ranch economy? On lands valuable as watersheds but with timber, forage, and recreational values as well, how can conflicts in use be most soundly compromised? How can the maximum returns from the multiple uses be achieved at the lowest possible cost to the people?

Meeting the responsibilities of public ownership is a challenging task. Social and economic relationship are woven through every problem arising from the job. Consequently, the station has a big responsibility to point its economics research program directly toward these questions. We, and our cooperators who are qualified to study facets of the overall problem, need to emphasize such investigations in the future. A piecemeal attack on border-region fragments of the problem, helpful as it is, will not lead to the soundest public land management.

ACCOMPLISHMENTS IN 1952 AND PLANS FOR 1953

Progress in 1952 was furthered materially through the cooperative projects already described or to be mentioned in the following pages. Cooperative agreements with one college, one university, and several individuals and industrial groups were formalized during the year. The following sections report in detail the accomplishments of 1952 and the plans for 1953.

Division of Forest Economics Research

A. Accomplishments in 1952

Economics of Forest Management, Utilization, and Marketing

1. Five important conclusions were developed from cooperative studies of resource problems and opportunities relating to pulp mill development in eastern Montana.

   a. There is sufficient timber east of the Continental Divide in Montana to support several pulp mills.

   b. Field development of the resource will require an intensification of forest management and the construction of many miles of road.

   c. One of the principal drawbacks to pulp mill development in this part of the State is the high cost of transporting wood from stump to mill.

   d. There are several places on the Missouri and Yellowstone Rivers where 200-ton pulp mills could be built without undue water pollution, if adequate safeguards are taken.

   e. Any pulp mill constitutes a pollution risk. Hence, legislation is needed to safeguard public interest before such mills are constructed.

   These are the high lights of Station Paper 34, "Resource Factors Affecting the Feasibility of Pulp Mills in Eastern Montana," and a companion report prepared by the United States Public Health Service in cooperation with the Montana Board of Health. The first report analyzes the timber situation in eastern Montana from the standpoint of the pulp mill opportunity. The latter deals with the water pollution problem as it relates to pulp mill developments.

2. Another large dam proposed for construction in western Montana poses problems in planning for use of forest resources. This is the proposed Libby Dam on the Kootenai River above Libby, Montana. Like the Hungry Horse Dam, it will create some major problems in protecting and developing the forest resource of the area. Therefore, the Forest Service has been prompted, in cooperation with the Corps of Engineers, U. S. Army, to undertake a study of the impact of the dam upon the local forest economy. The Division of Forest Economics is providing a forest economist to round out a study team, including a forester, road engineer, and logging engineer. In addition to measuring the seriousness of the impact of the dam on local forest transportation and travel and determining the most equitable solution to this problem, we feel that the study will provide a pattern for analyzing future problems of this kind in the West.

Forest Industry Analysis

3. The annual production survey shows that about 465,000 poles, 19 percent more than in 1950, were produced in the Northern Rocky Mountain Region during 1951. While this is a moderate increase, production is still 43 percent below the peak production year of 1947.

Comparison of pole production by species, 1947-1951

Species	1947	1948	1949	1950	1951
	----- Number of pieces -----				
Western redcedar	230,872	212,785	286,116	217,049	192,271
Lodgepole pine	351,310	138,099	186,262	92,338	136,628
Western larch	221,990	90,879	121,214	71,651	126,332
Douglas-fir	6,473	5,419	5,720	9,070	10,116
Total	810,645	447,182	599,312	390,108	465,347

Research Note 112 gives details of production by states, by length, and by A.S.A. class.

4. 1951 was the fourth consecutive year that Montana exported more than 3 million Christmas trees. This was also the sixth year of the last decade that Montana supplied the Nation's market with more than 3 million trees. Montana Christmas trees went to 20 states in 1952 with the mid-western states receiving most of them. Iowa imported 427,000 to lead the list. Ninety percent of the trees were shipped by rail. Research Note 107 gives other interesting facts about Montana's Christmas tree business in 1951.

Forest Resource Analysis

5. During the period 1910-1944 mortality in Montana's forests amounted to 25.6 billion board feet. The loss in those 35 years exceeded the cut by 26 percent. Half of that loss was caused by insects, one-fourth by fires, and the rest by diseases, windthrow, suppression, etc. Such is the problem that confronts the forest manager in his attempt to improve and increase the timber yields of Montana's forest lands.

The forests of Montana have the capacity to produce a far greater volume of wood than they are now producing. It is possible nearly to double the saw-timber cut. If these forests are made fully productive and are fully utilized, the cut of all timber can eventually be raised to about four times the 1948 level. At the same time, employment could be raised to an even greater degree by intensifying manufacturing.

These are some of the facts presented in U.S.D.A. Forest Resource Report No. 5, "Forest Resources of Montana." This report, prepared by S. Blair Hutchison and Paul D. Kemp, presents for the first time a complete appraisal of the forest resource from a timber industry standpoint based upon the first complete systematic survey of the timber resource in Montana.

Forest Survey

6. Slightly more than 2 million acres of forest land were inventoried in South Idaho during 1952. During the summer five field men from the station worked with men from the Intermountain Forest and Range Experiment Station and Region 4 establishing permanent sample plots and collecting forest inventory data. At the end of this second field season 2,496,000 acres of commercial forest land, 249,000 acres of noncommercial forest land, and 62,000 acres of reserved forest land have been inventoried in South Idaho.

   Compilation work for the 300,000-acre test survey conducted in 1951 in Southeast Idaho was nearly completed during the winter season. An appraisal of the relative cost and accuracy of four methods of forest type area determination being tested will be published at an early date.

7. About 105,000 acres of forest land were reinventoried in western Montana as a start on the maintenance survey of Montana. Field work was completed in Lincoln County on 60 locations representing 120 1/5-acre sample plots. These samples were taken at the request of the Kootenai National Forest to provide a better estimate of volume in pulpwood stands. The results of this work are to be used in the Libby Dam study.

8. Field work on the resurvey of North Idaho was completed during 1952 and compilation is about 90 percent finished. Northern Idaho was originally surveyed in the 1930's. Completion of the resurvey will make available up-to-date figures on forest area, volumes by size classes, condition of timber, current losses, use by industry, and similar information.

B. Plans for 1953

Economics of Forest Management, Utilization, and Marketing

1. The cooperative study relating to the impact of the proposed Libby Dam upon the local forest economy will be completed. We shall also prepare a report dealing with the techniques involved in making a study of this kind.

2. The study dealing with pulp mill opportunities in the Inland Empire will be renewed. Preliminary plans for this study were made last year but had to be set aside temporarily for the more urgent Libby Dam study. As part of the pulp mill study the United States Public

Health Service made a reconnaissance survey during August 1952 of the major streams of western Montana and northern Idaho. They are preparing a report on these streams based on these observations and upon available hydrologic data. Our report will include their evaluation of the water-supply outlook for a pulpmill industry.

Forest Industry Analysis

3. Sampling surveys will be conducted during 1953 to obtain estimates of the production of timber products. Plans have been prepared for these surveys and submitted to the Bureau of the Budget for approval. Such surveys are a part of the regular activities of the Forest Survey and provide information needed to keep our forest inventories up to date. In addition to our annual surveys of Christmas tree, pulpwood, and pole production, surveys will be made to obtain estimates of production and source of material for sawlogs, veneer, fuel wood, fence posts, mine timbers, and other miscellaneous products. Estimates derived from these surveys will be used in the Timber Resource Review of the Nation.

Forest Resource Analysis

4. Compilation of data for the reinventory of North Idaho will be completed and a statistical report prepared.

5. Inventory data for all of the Northern Rocky Mountain region will be checked and brought up to date for use in the Timber Resource Review.

Forest Survey

6. The initial forest inventory of South Idaho will be pushed during 1953. The field work in the Boise Basin now being carried on in cooperation with the Intermountain Station and Region 4 should be completed this year.

7. The maintenance survey of Lincoln County, Montana, started in 1952, will be completed this year. If funds and time permit, field work will be extended to Sanders County.

Division of Forest Management Research

A. Accomplishments in 1952

Natural and Artificial Regeneration

1. First-year results of seed dispersal studies showed that both larch and Douglas-fir seeds were scattered a maximum distance of 10 chains from the closest timber edge. However, seed

dispersal was insignificant in quantity beyond 4 chains for Douglas-fir and 6 chains for western larch. These early results came from a block clearcutting test comprised of one series of 15-, 30-, and 60-acre clear-cut blocks installed during the year in a larch--Douglas-fir stand on the Coram Experimental Forest. The purpose of the study is mainly to determine the effect of various sized openings on seed dissemination and seedling establishment, and the maximum sized opening which will restock satisfactorily within a 5- to 10-year period. Seedbed was prepared over most of the cut-over area by dozer scarification combined with slash disposal and broadcast burning where the slopes were too steep for machine work. Logging was timed with an abundant seed crop. Detailed seed dispersal data follow:

Distance from timber edge, (chains)	Western larch		Douglas-fir	
	Sound seed per acre	Compared with seed dispersed within reserve blocks	Sound seed per acre	Compared with seed dispersed within reserve blocks
	Number	Percent	Number	Percent
Within reserve timber block	238,709		192,971	
1	152,460	64	47,916	25
2	130,680	55	30,056	16
3	69,260	29	17,860	9
4	57,064	24	10,890	6
6	24,829	10	3,049	2
8	7,405	3	0	0
10	7,405	3	7,405	4
12	0	0	0	0

The reserve timber blocks, from which the seed was dispersed, contained 20 M board feet per acre, of which 75 percent was western larch. A lighter stand on the reserve blocks would have dispersed fewer seed, but the dispersal pattern with relation to distance from timber edge would probably have been similar.

2. The dispersal of sound lodgepole pine seed more than four chains beyond a timber edge is greatly limited. Most seed is dropped within the stand or one chain from it. These findings are based on three-year observations at White Sulphur Springs on the Lewis & Clark National Forest. While 33,000 sound seed per acre were produced within the reserved timber blocks, not more than 2,000 sound seed per acre, or six percent, were dispersed farther than one chain from the timber into adjacent clear-cut openings. Even though some seed traveled as far as seven chains, it appears that dispersal beyond four chains from the timber edge is not reliable.

Distance from timber edge (chains)	Number of sound seed per acre
Within reserve timber	33,000
0 (edge of timber)	18,000
1	4,000
2	2,000
3	2,000
4	2,000
5	0
6	0
7	2,000

These data emphasize the importance of taking advantage of the seed crop stored in the cones contained in lodgepole pine slash to obtain prompt regeneration. Studies of seedling establishment have shown that proper treatment of the slash to make effective use of seed stored in the cones will result in adequate stocking of clear-cut blocks, but destruction of the seed in the slash by burning frequently results in failure to restock. Clear-cut strips which depend upon seeding from the sides must be narrow (probably not to exceed two chains) for adequate lodgepole pine seed dissemination.

3. The impact of squirrels upon the seed crop of ponderosa pine is sufficient to nullify the benefits of seedbed preparation and may cause the virtual destruction of available seed. When seed crops are poor to fair, the rodents consume practically the entire crop. These conclusions come from seedbed preparation studies in cooperation with the J. Neils Lumber Company and from examination of cone crops on sample trees. Estimates made on the study areas in western Montana showed that squirrels removed about three-fourths of the cone crop. Only 1200 seeds per acre were dispersed from the fair 1951 cone crop. Even on scarified seed beds less than 25 seedlings had become established one year later.

A more detailed study of cones on 100 tagged branches on 8 trees in 1952, together with previous data on rodent seed consumption, emphasize the serious consequences of a rodent population on seed supply. The following data show the production of sound ponderosa pine seed in a cut-over stand in Bluesky Creek, Kootenai National Forest, for the period 1948-51.

Year	Total produced	Taken by squirrels	Dispersed	Taken by rodents after dispersal	Remainder available for germination
			Seeds per acre		
1948	1/	1/	75,600	69,800	5,800
1949	1/	1/	7,800	6,400	1,400
1950	1/	1/	200 2/	2/	600 2/
1951	41,600	31,200	10,400	7,300	3,100

1/ Undetermined.
2/ Data for 1950 erratic because of the extremely poor crop that year.

Data on dispersal of the 1952 crop are incomplete as yet, but it is known that the cone crop was poor. In the same trees being examined for squirrel damage, approximately 89 percent of the 1952 cones were cut by squirrels.

4. A fair ponderosa pine cone crop is forecast for 1953 in the Kootenai Forest section of western Montana. This prediction is based on observations of immature conelets on the branches of sample trees. The station has begun a study relating conelet production to cone production the following year in an effort to get seed supply predictions that will be useful in scheduling site preparation for the most effective dates. The following data, obtained on the tagged sample branches in the fall of 1952, are used as a basis for prediction of the 1953 crop:

	Number
Cones matured in 1951	104
Cones matured in 1952	9
Conelets that will mature in 1953	122

Thus it appears that the 1953 crop in the study area will probably be about equivalent to the 1951 crop.

5. Up-to-date forest tree planting instructions for the Inland Empire are now available. Planting instructions, summarized in a readily usable handbook (Station Miscellaneous Publication No. 5) emphasize techniques for severe sites. Although especially designed for planting ponderosa pine in the Inland Empire, the methods apply equally well to many other species and localities.

Silvicultural Studies

6. Studies in western white pine stands show that repeated light thinnings increase the proportion of white pine and result in superior diameter growth on selected trees. An analysis of growth data from a set of thinning plots established in 1914 on the Priest River Experimental Forest in a 55-year-old western white pine stand shows that the plot which was thinned three times (in 1914, 1924, and 1934) produced a net annual growth of 407 board feet of white pine per acre, while the unthinned plot produced only 249. The increase in white pine growth was attributed mainly to the increased proportion of white pine in the thinned stand. In total net cubic volume growth for all species, disregarding both mortality and material removed in thinnings, the unthinned plot was higher than any of the thinned plots. In board-foot volume growth, however, for all species, the plot thinned three times was slightly superior to the control, indicating that the growth was concentrated on fewer and larger trees. A plot thinned only twice (in 1914 and 1924) and another thinned only once in 1914 failed to produce as much total growth as the control plot.

The effect of thinning on stand composition

Treatment	Proportion of white pine cubic-foot volume in total stand		Increase
	1914 before thinning	1949	
	Percent	Percent	Percent
Control	40.9	42.5	1.6
Thinned three times	41.4	62.7	21.2
Thinned twice	26.1	45.6	19.5
Thinned once	27.3	35.1	7.8

Diameter growth of dominant and codominant trees following thinning

Treatment	Western white pine			Western larch		
	Average DBH		DBH growth	Average DBH		DBH growth
	1914	1949		1914	1949	
	Inches	Inches	Inches	Inches	Inches	Inches
Control	7.6	11.0	3.4	7.9	10.5	2.6
Thinned 3 times	7.2	12.5	5.3	7.6	11.4	3.8
Thinned twice	7.2	12.4	5.2	8.3	12.2	3.9
Thinned once	7.8	12.0	4.2	9.2	12.0	2.8

Another thinning experiment in a 45-year-old stand of western white pine and associated species on a poor site in the Deception Creek Experimental Forest showed, after 15 years, increased diameter growth on selected trees and an increase in the proportion of white pine in the stand. Total yields, however, were no greater and in some instances less than on the unthinned control plots regardless of thinning treatment, which included thinning from above at two intensities and thinning from below at two intensities.

Both of the thinning studies show that thinning in young stands must be light and frequent to accomplish increased growth on desirable trees and species and at the same time keep total production high. It is believed that thinning in young stands of the western white pine type will not generally be feasible until pulpwood markets develop.

7. A beginning was made in a study of thinning pulpwood sized ponderosa pine second growth. Two sets of five plots each were established to test various thinning methods for pulpwood and sawlog production. The plots, located on the Kaniksu National Forest, have not as yet been cut.

8. Analysis of the effect of seed tree, economic selective, and shelterwood cutting methods on logging costs in a larch--Douglas-fir stand showed that partial cutting increased the costs. The effects of cutting method upon costs were expressed mainly through their influence upon volumes removed and size of trees cut. The following table shows the effect upon logging costs of tree size and volume per acre, using the seed tree cutting as the base for comparison.

Method	Total cost per M.b.m. 1/	Increase or decrease in cost owing to:	
		Tree size	Volume cut per acre
	Dollars	Dollars	Dollars
Seed tree			
Ave. D.b.h. cut trees 18.6			
Vol. cut 19.3 M.b.m.	11.29	--	--
Economic selective			
Ave. D.b.h. cut trees 19.2			
Vol. cut 12.3 M.b.m.	14.66	- 0.25	+ 3.62
Shelterwood			
Ave. D.b.h. cut trees 17.9			
Vol. cut 9.2 M.b.m.	16.89	+ 0.38	+ 5.22

1/ Does not include hauling costs.

The study further showed that decrease in improvement costs and increase in volumes to be cut through reserve stand growth in old-growth larch--Douglas-fir timber may not be sufficiently great to offset the greater initial costs due to removing only part of the stand. It should be pointed out, however, that the cost of logging is only one factor to consider in choosing a method of cutting. Other factors such as the silvicultural requirements and cost of obtaining successful regeneration, earning from or loss of reserve trees, and special management objectives should also be considered.

9. A second cut was completed on a portion of the 1907-1911 selective cutting in Lick Creek on the Bitterroot National Forest. Previous studies in this stand have provided valuable information on growth and regeneration following the first cutting. When the initial cutting was made in 1907-11, a 75-year cutting cycle was planned. Recent studies of the reserve stand have shown that the second cut should have been made about 20 years after the original logging.

The second cutting removed 2,280 board feet per acre or a volume approximately equal to growth since the first cut. A stand of

relatively well-spaced, vigorous, mature and immature trees with a volume of 7,300 board feet per acre was reserved. Removal of rough dominants and thinning of "bull pine" groups gave considerable release to younger trees. Grade recovery from the light cut was somewhat similar to that expected from virgin stands. Approximately 15 percent of the lumber was in the select grade and nearly 1/3 was classified as #2 common. Grade recoveries for approximately 1/2 million board feet of ponderosa pine removed in the second cut are shown below:

Grade	Percent of Total
Select	14.7
Moulding stock	3.5
3rd clear shop	2.9
4/4 common shop	3.0
5/4 #3 & btr. shop	0.2
#2 common	31.1
#3 common	29.6
#4 common	10.3
#5 common	4.7
	100.0

10. Recommended silvicultural practices for lodgepole pine in Montana were summarized in Station Paper no. 33, published in July 1952. This report brings together the latest information we have in lodgepole pine silviculture based upon past experience here and elsewhere, field observations over the years, and recent experimental results. An abrupt increase in the utilization of lodgepole pine beginning in 1945 has created the need for sound guides to silvicultural practices. The recommendations offered in this paper will serve this purpose until an adequate research program can be undertaken in the lodgepole pine type in this region.

11. Studies of means to reduce timber losses caused by disease were continued. Though no major results can be reported for the past year, cooperative studies with other agencies were continued on pole blight of western white pine and silvicultural aids to control of white pine blister rust. The station organized text material submitted by agencies engaged in pole blight research and published a booklet, "Pole Blight- What Is Known About It." (Station Misc. Pub. no. 4.) The station again sponsored the annual conference of representatives of all agencies engaged in pole blight research. Slashing of unmerchantable standing material and prescribed burning were completed on an experimental area within the Deception Creek Experimental Forest testing a method of Ribes control in cooperation with the Office of Blister Rust Control of the Bureau of Entomology and Plant Quarantine and the Coeur d'Alene National Forest.

Mensuration

12. Tables for accurate prediction of ten-year cubic-foot growth for second-growth ponderosa pine in the Inland Empire were developed from measurements on nearly 5,000 individual trees. These tables, based on individual tree growth in relation to diameter and age, will give more accurate short-term growth predictions than normal yield tables because they require no adjustment for stocking. The tables, such as the one reproduced here, cover a range of site conditions and can readily be applied to a stand of young timber through a stand table derived from a simple cruise.

Converting factors for changing cubic volume growth to cordwood volume, International board-foot volume, and Scribner board-foot volume have also been prepared. Mortality corrections were included in the study. A manuscript on this growth study is ready for publication as a station paper.

13. Changes in stocking (normality) of western white pine are significantly correlated with initial stocking, age, and composition. These findings, based on growth data from 94 twenty-five-year-old permanent sample plots will permit greater accuracy of growth predictions based on Haig's normal yield tables for western white pine stands. Site index was not found to bear a significant relation to normality change in this study. Alignment charts have been prepared showing normality change in basal area, cubic-foot volume, and Scribner board-foot volume. Because of the large variation in mortality from one small area to another, normality changes are not accurate for small tracts but should be applied only to growth predictions for sizable areas.

Genetics

14. One-year-old white pine progenies of known parentage reflect inherent vigor of their parents. These findings are early results of a project designed to breed rust-resistant and otherwise superior white pine trees. Total height measurements of one-year-old progenies resulting from controlled pollinations in 1950 show that:

a. The average total height of progenies from different intraspecific crosses of rust-free trees ranged from 1.2 inches to 2.3 inches.

b. In spite of effects of seed weight, differences in time of germination, and other factors, a highly significant correlation was found between total heights of progenies and the average height growth of their parents.

c. Height growth of parents during the past 10 years correlated significantly better with progeny heights than did mean annual height growth. Thus, periodic growth for a comparable period in the development of each tree, such as the last ten years,

Future ten-year volume growth[1/] for ponderosa pine in the Inland Empire on Sites III, IV, and V

D.b.h.	Age in years														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
inches	Cubic feet															
2	0.30	0.14	0.08													
3	1.30	0.62	0.37	0.22	0.14											
4		1.30	0.80	0.56	0.42	0.32	0.26	0.22								
5		2.68	1.42	1.00	0.75	0.58	0.50	0.45	0.43							
6			2.65	1.95	1.55	1.30	1.05	0.90	0.75	0.65	0.60	0.55	0.53			
7			4.55	2.80	2.15	1.75	1.45	1.25	1.10	1.00	0.95	0.90	0.88	0.82		
8				4.75	3.50	2.85	2.38	2.05	1.80	1.60	1.46	1.35	1.27	1.20	1.16	1.15
9				7.50	5.40	4.40	3.77	3.33	3.00	2.72	2.50	2.30	2.18	2.07	2.00	1.95
10					7.45	6.10	5.25	4.65	4.20	3.90	3.63	3.46	3.32	3.22	3.19	3.15
11					10.40	8.05	6.70	5.90	5.30	4.80	4.50	4.22	4.05	3.90	3.80	3.75
12						10.60	8.90	7.75	6.95	6.35	5.90	5.50	5.25	5.00	4.85	4.75
13						13.70	11.20	9.80	8.80	8.10	7.50	7.05	6.70	6.40	6.20	6.05
14							13.20	11.40	10.30	9.40	8.80	8.30	7.90	7.50	7.30	7.10
15							16.35	14.10	12.60	11.50	10.70	10.00	9.50	9.05	8.70	8.40
16								17.20	15.00	13.40	12.30	11.50	10.80	10.20	9.75	9.40
17								20.50	18.40	16.60	15.20	14.10	13.30	12.55	12.00	11.50
18									21.10	19.00	17.35	16.00	15.00	14.20	13.50	13.00
19									24.50	22.00	20.20	19.00	18.10	17.40	16.80	16.40
20										25.50	23.30	21.70	20.50	19.50	18.80	18.15
21											26.10	24.40	23.20	22.30	21.60	21.00
22												29.10	27.20	25.50	24.10	23.00
23												32.40	30.50	28.90	27.60	26.50
24													34.00	31.60	29.80	28.50
25														35.50	33.80	32.40
26															37.60	36.00

1/ Includes stump and top without bark.

appears to be a better measure of inherent vigor than mean annual growth.

A tentative scheme for measuring inherent tendencies affecting tree form has been developed. Branch lengths and diameters are measured in the upper crown where effects of crown competition are minimized, and related to stem height and diameter growth. The system is being worked out for young white pine trees and may not be applicable to mature and overmature trees. Success of the method will not be known until the progenies are of sufficient size to permit comparable form measurements.

The rust-resistant tree breeding project is carried out in cooperation with the Bureau of Entomology and Plant Quarantine, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Northern Region, U. S. Forest Service.

15. The station continued to establish local field tests of hybrids developed by the California Forest and Range Experiment Station. Lodgepole x jack pine hybrid stock grown locally from seed furnished by the California Station were planted in three more plots for field testing. These plots are extensions of earlier plots established in central Montana, western Montana, and north Idaho in 1950.

Five-year-old lodgepole pine x jack pine hybrids in the above-mentioned localities continue to show vigor intermediate between that of the parents. The average total height in feet of each lot for all localities at the end of the fifth growing season is:

Jack pine (Minnesota) x wind	1.6
Lodgepole pine x jack pine hybrid	1.4
Lodgepole pine (California) x wind seed parent	.6
Lodgepole pine (Gallatin N.F., Montana) x wind	1.0
Lodgepole pine (Lolo N.F., Montana) x wind	.9

The hybrids and the jack pines on the test plots in central Montana suffered a severe setback during the winter of 1950-51.

Numerous crosses are being tested of western white pine x eastern white pine, western white pine x Himalayan white pine, and various racial crosses of ponderosa pine.

B. Plans for 1953

Natural Regeneration

1. Continue emphasis upon seed production and dispersal studies in ponderosa pine, larch--Douglas-fir, lodgepole pine and spruce-fir types. These studies will be broadened to include investigations of seed production, particularly of ponderosa pine and

larch in relation to the size, age, vigor, crown class, and release by logging. The impact of squirrels upon seed dispersal in ponderosa pine will be studied further in relation to population abundance. This will include cooperation with the Fish and Wildlife Service biologist to devise a squirrel census method.

Silviculture

2. Complete analysis of thinning experiments in western white pine and prepare final reports. This is a continuation of an analysis, partially completed last year, of all the station's thinning experiments.

3. Complete installation of an intermediate harvest cutting experiment for sawlog material in an immature white pine stand. This experiment, consisting of five treatments (two levels each of crown and selection thinnings and an unthinned control), is being established in a 75-year-old white pine stand on an excellent site in the Clearwater National Forest in cooperation with national forest personnel. It should provide needed information on intermediate harvest cuttings of sawlog material in white pine stands.

4. Continue studies of silvicultural means to reduce timber losses caused by disease. Cooperative studies of white pine pole blight with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the University of Idaho will be continued. Cooperative studies with the Blister Rust Control Office of the Bureau of Entomology and Plant Quarantine on method of Ribes control will also be continued on the Deception Creek Experimental Forest.

5. Begin a manuscript for U.S.D.A. publication on silviculture of the western white pine type. The latest major publication on western white pine silviculture was issued in 1942. Research, experience, and changing economic conditions since that date all make an up-to-date publication desirable.

6. Continue installation of ponderosa pine pulpwood cutting experiments. Plots have been established but not logged at one location. We hope to complete logging on the first plots and establish a set of plots at another location in 1953.

7. Complete installation of crop-tree thinning and pruning test in 40-year-old ponderosa pine. Plans for this experiment have been coordinated with similar studies being conducted by the Pacific Northwest Forest and Range Experiment Station. Thus, with a relatively small experiment in Montana, the adaptability to Montana conditions of extensive research conducted in the Pacific Northwest will be tested.

8. Complete installation of the alternate strip clear cutting experiment and begin preparation of border strip clearcutting in larch--Douglas-fir at the Coram Experimental Forest. These cuttings

will complete the series of presently contemplated major harvest cutting methods installed for research and demonstrational purposes in this timber type. The complete series will provide examples of the following:

1. Two types of strip clearcutting
2. Block clearcutting
3. Clearcutting with seed trees
4. Shelterwood cutting
5. Economic selective cutting.

Plans will be made to obtain replication of the series in future cuttings on the experimental forest or elsewhere in the region.

Mensuration

9. Complete analyses of site index changes, composition changes, and mortality in immature western white pine stands and prepare final reports. Records collected on permanent sample plots in immature western white pine stands during the past 25 years provide the basis for these analyses and reports.

Genetics

10. Begin studies to find ponderosa pine suitable for planting as a substitute for western white pine. Ponderosa pine frequently grows in mixture with western white pine on the fringes of the white pine type and on warmer and drier sites well within the type. It is believed that seed from this source might be suitable for planting ponderosa pine on certain areas which once grew white pine.

11. Continue cooperative work in search for and propagation and testing of rust resistant and otherwise superior white pines. The station's primary responsibility in this project is the improvement of silvical and timber-producing characteristics. However, we will continue to assist in pollination, propagation, and experimental design for other phases of the rust-resistant tree breeding program. A manuscript describing early results of studies to determine heritability of characteristics other than rust resistance, principally vigor and form, will be prepared in 1953.

12. Continue a small program of testing hybrids of 2-needle, 3-needle, and 5-needle pines developed by the California Forest and Range Experiment Station. The station's activities in this program will consist of the following: (a) Out-plant three-year-old ponderosa pine hybrids now growing in transplant beds at the Savenac Nursery; (b) grow seedlings from seed collected on local seed parents of lodgepole and ponderosa pine trees crossed with California pollen parents; (c) cooperate with the California Station in the selection of parent trees to develop hybrids adapted to specific localities.

Division of Range Research

A. Accomplishments in 1952

Artificial Range Revegetation

1. Nine forage species produced good to excellent stands in three northeastern Washington counties when spring planted on clean seedbeds.

Successful species	Location and season of planting					
	Ferry Co.		Lincoln Co.		Spokane Co.	
	Spring	Fall	Spring	Fall	Spring	Fall
	Stand rating					
Standard crested wheatgrass	Excel.	Good	Excel.	Poor	Excel.	Poor
Fairway crested wheatgrass	"	"	"	"	"	"
Crested wheatgrass, 571	"	"	"	Fair	"	"
Intermediate wheatgrass	Good	"	"	Poor	"	"
Siberian wheatgrass	Excel.	"	"	"	Good	"
Primar slender wheatgrass	"	"	"	"	Excel.	"
Pubescent wheatgrass	"	"	"	Failed	"	"
Manchar smooth brome	Good	"	"	Poor	Good	"
Orchard grass	Excel.	Poor	Good	Failed	"	Fair

Fall planted, these species did poorly or failed completely in two of the locations. Below-freezing temperatures without adequate snow cover, a common winter occurrence in northeastern Washington, were probably responsible for loss of new seedlings from fall plantings. These results strongly suggest the best adapted species as well as the proper season for planting on dry range areas in northeast Washington.

2. Thorough seedbed preparation nearly doubled the reseeded stand and resulting herbage production on formerly sagebrush-infested range land. Areas triple disked with an off-set disk and broadcast seeded early in 1951 were practically free of sagebrush and produced nearly three thousand pounds of grass herbage, air dried, per acre in 1952. Spring burning followed by single disking and broadcast seeding was almost as successful. Once over with an off-set disk followed by broadcasting on the other hand, gave only half as good a stand and a greatly reduced herbage production. Chemical spraying and fall burning to remove sagebrush, without follow-up reseeding, gave less than half and one-fourth as much herbage production, respectively, as triple disking and broadcasting.

3. First winter mortality of 13 spring-seeded forage species averaged 25 percent at 6,800 feet elevation on the Beaverhead National Forest. Kill was not random but rather irregularly distributed

in patches, suggesting a relation to depth or distribution of snow cover. The species affected were big bluegrass, green needlegrass, Russian wildrye, crested, bluestem, stiffhair, slender, and intermediate wheatgrasses, tall oatgrass, meadow and Lincoln brome, hard fescue, and orchardgrass. Similar winter kill of young plants was recorded in field plantings at 3,200 feet near Missoula.

4. Broadcast seeding immediately following seedbed preparation produced better seedling stands of reseeded forage species in high mountain meadows than did drilling. Seedling stands increased directly with degree of seedbed preparation from single to triple treatment with a tandem disk. Plowing plus single disking showed no advantage over triple disking.

Number of grass seedlings per 1'x2' plot by seeding methods and seedbeds

Method	Check	Tandem disked once	Tandem disked twice	Tandem disked three times	Plowed and tandem disked once	Horse disked twice	Ave. for seeding methods
Drilled	0.6	5.5	8.5	10.9	7.9	5.0	6.4
Broadcast and Harrowed	0.6	5.2	9.8	10.6	12.0	7.0	7.5
Average	0.6	5.35	9.15	10.75	9.95	6.0	

5. Surveys and tests of portable equipment for preparing seedbeds in alpine meadows and other poorly accessible areas have indicated that a four-foot tandem disk and a hydraulic field cultivator are most suitable. Both of these implements can be readily disassembled for packing on mules. Some modifications are needed for easy operation as horse-drawn machines.

6. New data were gathered from the Judith Basin Area for incorporation into the manuscript "Reseeding Formerly Plowed Range Lands in Central Montana." This manuscript, now up to date, is nearing publication.

7. A major revision of Farmers' Bulletin 1924 containing the best available information on reseeding range lands in Montana was published and distributed.

Management of Summer Ranges

8. Even though the 1952 grazing season was the driest since 1936, mixed cattle on mountain summer range gained weight comparable to usual feedlot performance over the 142-day period. Dry cows made

the greatest gain, 3.0 lbs. per day; yearling and two-year-old heifers somewhat less, 2.1 lbs. per day; and wet cows the least, 1.4 lbs. per day. These gains in the aggregate, valued at nearly $11,000 and averaging over $3.30 per acre of available range, strongly indicate the high grazing potential of many mountain summer ranges in central Montana.

9. Irregular beef cattle breeding programs and other poor cattle management practices explain low calf crops and light calf weights on Vigilante Experimental Range. Sixteen percent of the calves weighed out of the Vigilante pasture on October 28 were dropped on the summer range after June 7, the opening date. These calves averaged only 248 pounds in weight at the close of the summer grazing season. Spring and summer calves combined constituted only a 77 percent calf crop for the Vigilante permittee. Such findings, typical of upper Ruby operations, provide a basis for strong recommendations concerning livestock handling and management practices on ranches using this national forest range in the yearlong operation.

10. Utilization surveys revealed better distribution of grazing use in 1952 than at any time in the past. Lack of snow and low temperatures throughout the grazing season permitted range cattle to remain well distributed, even up to 9,000 feet elevations, until removed from the range on October 28. Concentrations at the lower elevations because of snow during the last few weeks of the grazing season is the usual pattern.

Management of Short-grass Ranges

11. Occurrence of the driest season since 1936 forced experimental cattle out of the summer pastures at Miles City early in September. In spite of this situation, it was possible to return the animals to the experiment at the start of the winter grazing period. At that time the first replacement of parental cows by F1 bred heifers was effected. Two heifers born in each of the six experimental pastures and since maintained at the same relative level of range stocking were returned to their original pastures to start the rotation of successive generations of cattle into the study. Four additional years will be required to complete the replacement of parental cows with first generation heifers.

12. Calf weights on short-grass experimental ranges stocked at three levels, heavy, moderate, and light, increased in 1952, compared to previous years, with increasing age of cows in spite of drought and low forage production. The effect of stocking intensity on calf weights was evident in the smaller increase from 1950 to 1952 under heavy than under moderate and light stocking. Early September weights were used for this comparison because drought forced the end of the summer grazing season on September 4 this year.

Early September calf weights -- 3 years

Intensity of Range Stocking	1950 (3-yr.-old cows)	1951 (4-yr.-old cows)	1952 (5-yr.-old cows)
	---	Pounds	---
Heavy	310	305	331
Moderate	324	331	383
Light	336	359	383

Noxious Plant Control

13. The density of native forage grasses increased 39 percent on a mountain summer range the first year following spraying with 2,4-D for Wyethia control. A commercial formulation of isopropyl ester was applied at a concentration of 2000 ppm. in 90 gallons of water per acre. Only one percent of the Wyethia plants were unaffected by the spray, and 60 percent completely disappeared. Other forbs decreased 44 percent, and 69 percent of the sagebrush was killed by the treatment.

14. Peripheral plants in Klamath weed stands grow taller and produce more summer foliage, fall regrowth, and seed than plants growing in the interior of dense stands. The following data came from ecological studies of Klamath weed, made to improve knowledge of growth habits upon which successful control must be based.

Plant Character	Kettle Falls site		Spokane site	
	Peripheral	Central	Peripheral	Central
Mature height (inches)			15.5	13.6
Flowering (percent plants)			100	82
Height fall regrowth (inches)			1.4	0.4
Fall regrowth (percent plants)			100	56
Stems per plant	10	2	10	4
Capsules per stem	98	37	99	28
Seeds per capsule	72	73	56	38
Seeds per plant	75,503	5,841	54,005	4,979

15. Klamath weed beetles (Chrysolina gemellata) released in northeast Washington in 1951 show promise of becoming successfully established. Beetles survived at all release points throughout the past season despite the unfavorably dry conditions that predominated. Abnormally low fall precipitation and consequent lack of fall growth may have affected normal breeding and egg-laying activities. Upon several occasions, however, eggs were observed during late fall examinations of all release areas.

B. Plans for 1953

Artificial Range Revegetation

1. Continue observations of species performance in adaptation tests to include: (a) nurseries, (b) skid road and trail study, (c) Bremner Bench grazing test, and (d) a planting made on an area from which road surfacing material was obtained.

2. Summarize and publish results of the species adaptation trials carried on at the four adaptation nurseries in the Inland Empire.

3. Install necessary cross fences at the Bremner Ranch and develop stock watering plan. This constitutes necessary preparation for cattle grazing tests to start in 1954 on a pilot reseeding test area.

4. Reexamine reseeded areas in Bear Gulch and on Argenta Flats, Beaverhead National Forest, particularly from the standpoint of evaluating relative adaptation of species planted.

5. Initiate an exploratory study of the feasibility of reseeding cheatgrass-infested range lands without ground preparation but in connection with applications of growth-inhibiting herbicides. Such a study is desirable because of the impracticality of ground preparation on many cheatgrass sites.

6. Study utilization of reseeded species by cattle on Dry Fawn Creek area, Beaverhead National Forest, established in the spring of 1951. Assessment of relative use by species is needed to complete the picture of the value of reseeding, following sagebrush removal on this national forest summer range.

7. Follow up Carrot Basin tests (Gallatin National Forest) of species adaptation and of seeding methods on reseeding success at high altitudes. This will involve measures of stand and herbage production. Correlate with this study further testing of seedbed equipment to the extent possible with funds provided by the reseeding committee.

Management of Summer Ranges

8. Consider, with the Division of Range and Wildlife Management and the Beaverhead Forest, the possibilities of strengthening the Vigilante program and of making desirable changes in the range-cattle management study. Subdivision of the Vigilante Experimental Range or establishment of a new area is needed to provide an opportunity for adequate study of stocking intensities, seasons of use, or other important aspects of mountain summer range management.

9. Strengthen the study of beef cattle weights and gains and of cattle management practices by endeavoring to obtain more adequate numbers of the various classes of cattle and the return of as many animals as possible once grazed in the Vigilante pasture. There is an urgent need for weight and gain data on dry cows and steers using the Upper Ruby Range.

Management of Short-grass Ranges

10. Weather conditions permitting, continue the cooperative cattle grazing study of stocking at three intensities. Special attention will be given to the development of sampling schemes and study plans involving range vegetation and soils and to the rotation of a new group of F1 heifers into the experiment.

Noxious Range Plant Control

11. Follow up on the study of the effects of thirteen herbicides and soil sterilants on Delphinium glaucescens initiated in 1952. Chemicals showing promise of retarding the growth of this poisonous plant sufficiently to cause death eventually will be further tested.

12. Continue the ecological study of Klamath weed and Klamath weed beetles in the Upper Columbia and Inland Empire Research Center areas. Prepare manuscript for publication as a research note on results of the Colville Mountain Klamath weed control study.

Division of Fire Research

Cooperation by private, state, and federal agencies is providing expanded opportunities to perform research on many of the major problems in western fire control. In the station's annual report for 1951 the Division of Fire Research reported completion of projects in fire behavior and fire control. The knowledge gained in these projects provided the foundation for new attacks on such problems as logging slash hazards, lightning fire control, fire detection, and fire danger rating. However, the limited staff and facilities of the Division of Fire Research offered little hope that research progress on these problems could keep pace with the needs and opportunities. Development of an expanded cooperative research program is providing a means of undertaking part of the needed work. During 1952 ten private, state, and federal agencies joined forces in a coordinated fire research program.

A. Accomplishments in 1952

Inflammability and Fire Behavior

1. A field laboratory for logging slash research has been established at the Priest River Experimental Forest. When the planned facilities at this laboratory are completed, it will be possible to study the inflammability of logging slash through all the stages from creation of the hazard at the tree-falling site to natural deterioration or artificial control in the woods. As a result it is expected that more efficient and possibly less costly logging slash control methods

can be developed. The development of the Priest River Laboratory is being performed primarily in cooperation with the University of Idaho, but in addition the Idaho State Forestry Department, the Priest Lake Timber Protective Association, Potlatch Forests, Inc., the Kaniksu National Forest, Region 1 smokejumpers, the U. S. Weather Bureau, and the California Forest and Range Experiment Station assisted in the work accomplished during 1952. Over 150 slash plots were established where inflammability could be measured for various tree species and amounts of fuel in controlled burning tests.

2. Initial tests show that logging slash becomes moderately inflammable within one week after creation. Preliminary studies at the Priest River Laboratory show that the living crown is much drier in some species than in others and that the finer portions of entire branches dry to a moderately inflammable condition within one week after a tree is felled. Moisture variations in slash are also being studied in relation to measured weather factors, change of color in needles, and needle dropping. These studies are expected to provide useful and practical means for determining inflammability and, as a result, for planning improved slash disposal operations or making better estimates of the behavior of slash fires.

3. Experimental burning of 60 plots shows that of many factors, quantity of slash is of key importance in inflammability. During the summer of 1952 plots of identical size containing three different amounts of slash for each of four species were burned at the Priest River Laboratory. The amount of slash was determined by dry weight with three weight classifications used: light slash being 7.5 tons per acre; medium slash, 20 tons; and heavy slash, 32.5 tons. In all cases the fastest rate of spread of fire was observed in the heavy slash plots. The results of these studies, when combined with studies by the University of Idaho of volume of slash per thousand board feet cut, may enable slash hazards to be estimated accurately in advance of timber cutting. Another result of the slash burning tests showed that species which retained their needles burned hotter and faster than those from which needles dropped as they dried. Time-lapse motion pictures in color were obtained of all experimental slash fires.

4. Chipping of logging slash results in a spectacular reduction in inflammability. At Priest River 96 experimental burning plots of eight tree species and three weights for each species were established with slash treated by a chipping machine. Burning of 24 chipped slash plots clearly showed a great reduction in inflammability as compared to natural slash plots. Chipped slash burns at a rate similar to duff of the same species. The main difficulty preventing widespread use of chipping as a means of slash control is the present high cost of this type of operation. Development of more economical systems for slash chipping would be of great significance to western forestry.

5. Multiple ignition provides a new technique for increasing the efficiency of prescribed burning operations. Successful management of northern Rocky Mountain forests calls for an increased use of controlled fires to dispose of logging slash, reduce fuels in snag areas and blowdowns, control Ribes, and prepare planting sites. When these fires are started, they may be more effectively regulated by means of igniters placed at numerous points to provide rapid generation of heat and the pulling of the fire in the desired directions. Preliminary tests performed in 1952 in cooperation with the California Forest and Range Experiment Station showed that the principle of multiple ignition is sound. The next step in exploring this technique is development of a hotter, more sure-firing igniter which will provide instant heat at the desired points. Several types of electrical and hand-fired igniters were tested in 1952, but none proved fully satisfactory in firing heavy forest fuels.

6. The NRM experimental rate-of-spread computer assists dispatchers and fire fighters make accurate estimates of fire behavior in dangerous fuels. Results from a 2-year field test show that the computer, which integrates ratings of fuel, weather, and topography, is most accurate in predicting rate of spread of fires in flash fuels. The predictions obtained by the computer are less accurate in fuel types where fires normally spread at a lower rate. The field tests initiated in 1951 were continued during 1952 at six ranger stations and two national forest headquarters where dispatchers compared predicted with actual rate of spread on each fire reported. Results of the 2-year study will now be analyzed to determine whether further development and refinement of a computing device is justified.

Fire Danger Rating

7. Efficiency of fire danger rating system has been increased. In 1951 the Station and the Region 1 Division of Fire Control, with the cooperation of the U. S. Weather Bureau, established a project to promote more effective measurement and rating of fire danger throughout the northern Rocky Mountain region. The program is designed to determine the best location for fire danger stations; provide better weather instruments; and train personnel for more accurate observation, measurement, and reporting of fire-weather conditions. During 1952 preliminary field work in studies of fire station locations was completed on 17 national forests, one national park, and one state fire protection district. Weather instruments from nearly 100 stations were repaired and calibrated at a central repair shop in Missoula.

8. Fuel moisture stick manufacturing process improved. During 1952 a new fuel moisture stick manufacturing center was established at the Forest Service warehouse in Spokane. The manufacturing process is now on a mass production basis with over 2,000 sets of fuel moisture sticks being produced for forest protection agencies in the western United States, Canada, and Alaska. The Spokane manufacturing center is the only source of the 100-gram fuel moisture stick used by all western forest protection organizations. Personnel at the Spokane

warehouse developed a machine for automatic sorting of ponderosa pine doweling stock used in stick manufacture. Other improvements were made in oven-drying procedures, stick assembly, inspection, and packaging. A testing program was established at the Priest River Experimental Forest to check the accuracy and dependability of fuel moisture sticks. A manual was prepared on the entire manufacturing process.

9. Improved methods were developed for rating the moisture content of flash fuels. Field tests conducted in 1951 and 1952 show that basswood slats provide a better fuel moisture indicator than ponderosa pine sticks for rating the moisture content and inflammability of cured grass and other flashy fuels. Basswood slats, which are widely used in the eastern United States for fuel moisture measurements, provide an indicator that is more sensitive to changes in relative humidity and precipitation. As a result of this faster reaction, the basswood slats are superior in evaluating hour-to-hour changes in very light fuels. However, the ponderosa pine sticks are superior for rating inflammability in heavier forest fuels. A Research Note, "Inflammability Ratings for Flash Fuels," by Charles E. Hardy, has been prepared to explain results of experiments conducted to date.

Lightning Fire Prevention

10. Cooperation by several agencies opens a new opportunity for research in the control of lightning fires. In 1952 a lightning fire research project was established in cooperation with the General Electric Research Laboratory and the Munitalp Foundation. Objectives of the project are: (a) to obtain a better understanding of the occurrence and general characteristics of lightning storms and lightning fires in the northern Rocky Mountain region, (b) to assist in obtaining and analyzing fire-weather information needed in research projects of the U. S. Forest Service and the Munitalp Atmospheric Research Project, and (c) to determine the possibility of preventing or reducing lightning fires by weather modification operations. Dr. Vincent J. Schaefer of the General Electric Research Laboratory will be the technical director of the project. As the project progresses it is hoped that technical assistance may be obtained from the U. S. Weather Bureau and several of the colleges and universities in the Northwest. During 1952 Dr. Schaefer and Vernon Crudge, Director of the Munitalp Foundation, a privately financed research institution which is sponsoring part of the planned program, visited the region to assist in the initial development of field work.

11. Time-lapse motion pictures reveal basic characteristics of lightning storms. During 1952 Dr. Schaefer initiated a program at four northern Rocky Mountain fire lookout stations to obtain time-lapse motion pictures of lightning storms and other cloud conditions associated with the occurrence and behavior of lightning fires. The time-lapse motion picture camera enables the number

of film frames exposed per minute to be controlled at a rate desirable for research purposes. As a result, several hours of cloud action may be condensed into a few minutes of film time. Motion pictures obtained by this method reveal the action of clouds in a storm from initial buildup through to the lightning stage. Filming of clouds from lookout stations in 1952 were only exploratory efforts, but they show that this research method offers great promise in documenting significant features of lightning storms and lightning fires. Background studies of this type are essential steps needed before controlled experiments can be undertaken of the possibility of lightning prevention.

B. Plans for 1953

1. Logging slash research will be continued. Burning tests at the Priest River field laboratory will be continued in cooperation with the University of Idaho. Additional slash study plots will be established, if the necessary manpower and facilities are available. Results of work performed to date will be evaluated with a view to publication of preliminary findings at the earliest possible date. First tests will be made of the inflammability of one-year-old slash as compared to fresh slash.

2. General fire behavior research will be continued. Studies during the next year will be focused on (a) behavior and techniques of burning on prescribed fires, (b) analysis of factors causing "blowup fires," and (c) further development of a rate-of-spread computer.

3. Fire danger rating research will be concentrated on development of an improved burning index meter. As a preliminary step in the development of a new burning index meter, an analysis will be started of fire-weather records. Progress in this field will be contingent upon the development of a suitable punch card system for coding and recording fire-weather data obtained from stations throughout the northern Rocky Mountain area. Other work in fire danger rating will include: (a) continued work in the development of an improved fire danger rating network, (b) technical guidance in fuel moisture stick manufacturing, (c) field studies of fuel moisture in both flash and heavy fuels, and (d) preparation of a 20-year summary showing the relative severity of each fire season during the period 1934-1953.

4. Cooperative work in lightning fire research will be expanded. In cooperation with the Munitalp Foundation and 10 national forests, a cloud survey will be initiated at 25 lookout stations in western Montana and northern Idaho. At each of these stations a daily summary will be made of the development and movement of clouds. Special observations will be made of each lightning storm. This phase of the project is expected to provide essential background information for future tests in the prevention of lightning fires. Preliminary studies will be made of the relationship of the jet stream to lightning fire occurrence and behavior. Time-lapse motion pictures will be obtained of cloud and lightning fire conditions.

5. Cooperative studies of aerial detection will be continued in cooperation with the Region 1 Division of Fire Control. The station will prepare a design for an analysis of the effectiveness of aerial detection on the national forests.

Forest Utilization Service

A. Accomplishments in 1952

1. Limitations to pulp mill development on some parts of the Yellowstone River due to existing pollution or insufficient water volume were found in a study completed during the year. The study and a final report were made by L. F. Warrick and H. A. Anderson of the Washington Office of the Public Health Service as a result of cooperative field work with the Forest Utilization Service, the Montana Public Health Service, the Montana Power Company, and other interested agencies. The present heavy pollution load at Billings would make a pulp mill located in that area highly undesirable unless current pollution were curtailed. Even though pollution is not heavy at Livingston at present, there is a narrow safety factor there due to the comparatively low winter flows in some years. Hence, it seems that more logical locations are along the Missouri at Three Forks, a point between there and Townsend, or immediately below Great Falls. The location of a 200-ton sulfate pulp mill would be feasible at any one of these points without significant effects on fish and other aquatic life.

2. A modified crosshatch piling of lodgepole pine poles produced more satisfactory drying than tighter crosshatch piling. In addition, an electric moisture meter proved an acceptable means for determining the average moisture content and its distribution in lodgepole pine poles. These results and others are contained in the final report on the lodgepole pine pole air-seasoning study conducted by the Madison Laboratory in cooperation with the J. Neils Lumber Company, Libby, Montana. Copies of this report, No. R1922, "Air Seasoning of Lodgepole Pine Poles," are now available.

   The moisture contents of lodgepole pine poles in three different piles were studied. In one pile two 8-pole layers were placed at right angles to each other on the foundation, 40 poles in the third layer, 8 poles in the fourth layer, and so on until 21 layers were completed. This arrangement was designated as the "modified crosshatch pile." In two other piles, consecutive layers were piled at right angles to each other. This type of pile was called "crosshatch."

   The study showed that (a) average moisture meter readings taken at a depth of 0.15 of the diameter of the pole at the ground line checked well with the average moisture content determined by the oven drying method; (b) moisture meter readings taken at a depth of 0.15 of the diameter at the ground line of poles accessible

from the outside of the pile are a good practical indication of when the entire pile is below 30 percent moisture content; (c) considerably more stain and mold occurred in the two crosshatch piles than in the more open modified crosshatch pile; (d) placing the top ends of poles to the north is advantageous in reducing checking of such ends; (e) during air seasoning from the green condition to 20 percent moisture content, the average circumferential shrinkage at the ground line of sample poles was about 1.3 percent of the green pole circumference; and (f) sample poles in the modified crosshatch pile erected July 28, 1950, reached an average moisture content of about 22 percent in 46 days.

3. The effect of spiral grain in western larch poles on the distortion of crossarms is negligible if poles are air seasoned properly. Such was a preliminary conclusion reached in a cooperative study of grain twist and other pole characteristics started during the year. Three cooperators: Poles, Incorporated of Newport, Washington; B. J. Carney Company, Spokane, Washington; and Schaefer-Hitchcock Company, Sandpoint, Idaho, are working with the station on this project which is centered at the Inland Empire Research Center in Spokane. The eventual objective of this study is to correlate use characteristics of western larch poles with the growth characteristics of a western larch pole stand on the Priest River Experimental Forest.

A survey of larch poles in use, the first phase of the study, has been completed. Some conclusions are: (a) in poles with spiral grain the twist was counterclockwise in 75 percent and clockwise in 25 percent of the poles examined; (b) a negligible number of poles had sufficient distortion of grain to cause significant distortion of the crossarm and the line; (c) no significant line distortion was found in those lines where the poles had been sufficiently air-seasoned before being placed in service; and (d) there were no line failures in the four lines examined because of twist of grain.

A further study of spiral grain in relation to moisture content and other factors is underway at the yard of one of the cooperators at Newport, Washington. In this study, 40 poles with two replications in each of 20 categories have been erected. Forty and forty-five foot poles, classes 3, 4, and 5, are being used. Green poles and those seasoned one, two, and three years are represented in pairs in the following categories: straight grained, moderate clockwise spiral, severe clockwise spiral, moderate counterclockwise spiral, and severe counterclockwise spiral. Observations of these poles during the next two or three years should indicate whether or not the seasoning of larch poles will eliminate any distortion in the crossarm section of the pole due to spiral.

4. Newsprint made from thinnings of 40-year-old ponderosa pine timber was found to be intermediate in quality between that of southern pine and spruce. Tests at the Madison Laboratory showed that the thinnings yielded experimental groundwood pulps that were equal in strength to an average of 29 commercial newsprint grade groundwood

pulps previously tested at the Laboratory. Tearing and tensil strength of newsprint made from ponderosa pine thinnings was equal to an average of 56 commercial newsprint papers tested. However, the bursting strength of the sample newsprint was 20 percent lower than for these same 56 commercial papers, but still is considered higher than that of samples of commercial southern pine newsprint paper now being produced and used in the South. The Madison Laboratory also made a book paper from ponderosa pine thinnings that was up to standard strength. Pulps of good quality can be made from this wood at normal consumption of energy. Material used in the tests was practically all sapwood, with only about 1 percent heartwood by volume. Sticks averaged 5.2 inches in diameter.

5. The suitability of pole-blighted Idaho white pine timber for pulp and paper production is being determined by the Madison Laboratory. One cord of young, sound, unblighted western white pine, and one cord of blighted western white pine timber were furnished the Madison Laboratory for testing during the quarter. Tests have already shown that even sound green western white pine makes a poor sulfite pulp. Hence, it was considered without point to test sulphite pulping of the pole-blighted material. Therefore, the Madison Laboratory will test these samples and furnish information on the following: (a) the physical appraisal of the wood, (b) a report on sulfate pulping, and (c) a report on groundwood pulping.

6. The many utilization problems created by the current Engelmann spruce bark beetle epidemic have been pin pointed by a preliminary survey just completed. At many plants seasoning was found to be one of the principal problems in spruce lumber production.

Much of the lumber end checks and splits badly due to its low initial moisture content and low summer humidities in this area. Better methods of air seasoning and kiln drying should remedy this difficulty. It was concluded that lumber cut from Engelmann spruce infested during the past summer will show little or no depreciation during 1953, dependent, of course, upon the dryness of the season. Checking and some sap rot can be expected in the logs by 1954. In all probability salvage of the timber for lumber production cannot be planned beyond three years after the initial infestation. According to Dr. Ralph Lindgren, Forest Pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, who cooperated in the survey, deterioration of trees from a pulp utilization standpoint was more rapid in this area than in Colorado. We should probably not plan on the use of bug-killed material for pulp beyond 10 or 15 years after the death of the trees. More rapid deterioration in the northern Rocky Mountain area is, of course, due to humid weather conducive to decay.

B. Plans for 1953

1. Air seasoning study of western larch power poles will be started in cooperation with the J. Neils Lumber Company. Final arrangements will be made for participation of the Madison Laboratory in the study. Pole piles will be erected for observation by June 1 if weather conditions permit. A suitable air seasoning cycle will be determined for poles of all size classes giving particular emphasis to poles over 50 feet in length.

2. Arrange for development and dissemination of information on utilization of beetle-killed Engelmann spruce. An effort will be made to develop and disseminate as complete information as possible on the following phases of this problem:

   a. Grade recovery of beetle-infested timber one and two years after infestation.

   b. Rate of deterioration of sapwood in standing timber.

   c. Rate of deterioration of logs in dry as well as water storage.

   d. Factors affecting lumber storage over several years and consequent grade depreciation.

   e. Current factors affecting the Engelmann spruce lumber market, including importation of Canadian spruce and the possibility of substituting Engelmann spruce for ponderosa pine and other species.

   f. A summarization of all known data on the properties and uses of Engelmann spruce.

3. Utilization problems of Douglas-fir throughout its range will be studied. Encroachment of Douglas-fir on pine and larch sites has created serious silvicultural and utilization problems throughout the forests of eastern Washington, North Idaho, and Montana. Douglas-fir growth habits and characteristics in relation to utilization factors will be surveyed in an attempt to outline a utilization research program. Eventually a long term cooperative study by the Northern Rocky Mountain Forest and Range Experiment Station and the Forest Products Laboratory will be developed to determine, (a) relationship of growth condition to wood quality, and (b) possibilities of improving quality by growth control or other methods.

4. Testing of Northern Rocky Mountain species for pulp and paper making properties will continue. Information developed at the Madison Laboratory will be disseminated to interested individuals and agencies. Tests are currently being made on alpine fir and pole-blighted western white pine.

5. Study of grain twist and other pole characteristics of western larch poles will be continued. This is a cooperative study between the pole industry and the Inland Empire Research Center. The Forest Utilization Service will continue as a facilitating agency and liaison with the Forest Products Laboratory.

Division of Flood Control Surveys

At mid-year funds for flood control surveys were curtailed to such an extent that the project was placed on a liquidating basis. All advance flood control studies were terminated and only one man was retained on the job to complete the flood control portion of the Columbia Basin Agricultural Program. Personnel were not available to compile and analyze accumulated data from these studies.

Early in 1952 subdivision boundaries within the Columbia Basin were revised and the station assigned major responsibility for two of the 11 subdivisions. The Clearwater, Spokane, and Colville drainages, plus small contiguous areas in North Idaho and Northeast Washington, make up one subdivision. The United States portions of the Clark Fork-Pend Oreille, Kootenai, and St. Mary drainages comprise the other. The latter is known as the Upper Columbia area and is one of the four subdivisions of the Basin for which a supplement report is being prepared at this time.

A. Accomplishments in 1952

Flood Control Survey of the Columbia River Basin

1. Completed land area statistics for the two subdivisions in the Northern Rocky Mountain area classifies approximately 81 percent of the combined subdivisions as forest land. These statistics, now in final form, account for the 31,096,663 acres in our area of responsibility by major kinds of ownership and cover type. The land area is classified generally as follows:

Subdivision	Total area	Major cover type			
		Forest	Range	Cropland	Other
	Acres	Percent			
Clearwater-Spokane-Colville	11,881,493	78	7	13	2
Upper Columbia	19,215,170	83	10	4	3

Forest land is classified further into eight cover types; range land into four nonforest types; and cropland into irrigated and

nonirrigated. Ownership is broken into nine categories. The task of correlating these figures among all the subdivisions of the Basin and obtaining final acceptance by all agencies and political units concerned was considerable, and was basic to development of the program.

2. The comprehensive agricultural program for public range and all forested land was compiled and coordinated with the program for other portions of the Columbia Basin, in cooperation with national forest administration.

3. Preliminary evaluation of an intensified program for forest and public range land development in the Northern Rocky Mountain area indicates an annual increase in production of approximately 1.5 billion board feet of lumber, 185 million cubic feet of other wood products, and 115 thousand animal unit-months of forage. Beside these benefits in increased production, the land treatment phases of the forest and public range land program are expected to reduce flood, erosion, and sediment damages within the Northern Rocky Mountain area by roughly $1,500,000 annually. The above figures are exclusive of the program on cropland.

4. Basic data and preliminary write-ups for the basin-wide report are essentially completed and have been sent to the U.S.D.A. Field Committee which will assemble, correlate, and combine into the basin-wide report material from all cooperating agencies. Some of the completed sections of the composite report have been edited by this station.

5. Narrative material for the Upper Columbia area described physiography, geology, soils, climate, surface and ground water resources, and land cover types and condition has been prepared for submission to the assembling office. Maps covering the same material have been prepared and sent to the Field Committee for final correlation and drafting.

Supplemental Advance Flood Control Studies

6. Sixteen special snow courses were measured through the 1952 melt season to supplement data from courses at the Priest River Experimental Forest, the Upper Columbia Snow Laboratory, and Soil Conservation Service courses. Climatological and snow accumulation and melt data were obtained during March through June at the Upper Columbia Snow Laboratory. As previously explained, none of these data have been compiled.

7. Peak flow, flood frequencies, and other hydrologic data were collected and compiled for North Idaho and Northeast Washington. This completed the stream-flow data used in the hydrologic analysis for the Columbia Basin report.

8. From an analysis of the relationship between cover conditions, snow accumulation and melt, and streamflow peaks, it was found

that the accelerated land treatment program can be expected to reduce flood peaks in our area from 8 to 11 percent in the various sample watersheds.

9. Measurement of snow evaporation by weighing snow cores was tested in the spring of 1952. Though the method appeared promising, termination of the project prevented analysis of the data and refinement of the techniques.

10. The station cooperated with the University of Idaho Engineering Experiment Station in testing experimental wind-shields for precipitation gauges. One of the University's field test installations is located on Gisborne Mountain, within the Priest River Experimental Forest, on a windy south-facing slope at an elevation of 5,500 feet. Biweekly measurements of test gauges were continued through 1952 to test in the field several wind-shields developed by the University through wind tunnel studies.

B. Plans for 1953

1. The Columbia Basin Agricultural Report is scheduled for completion in 1953. Requests for data and for assistance in review are expected to continue through the final stages of preparation of the basin-wide report.

2. The Upper Columbia supplemental report is to be completed in 1953. The narrative section on water problems will be completed at an early date. Economic analysis of the program including benefit-cost ratio determination will be one of the major tasks.

Infiltration Project

The Priest River infiltration project was started in May 1952 as an extension of the Vicksburg (Mississippi) Infiltration Project. The project is conducted by the Forest Service for the U. S. Army Corps of Engineers' Waterways Experiment Station at Vicksburg, Mississippi. Three men have been assigned to the study. So far their efforts have been confined primarily to installing field apparatus and obtaining infiltration and related records. Analysis of data, currently under way, should provide results of interest for the next annual report.

A. Accomplishments in 1952

1. Moisture infiltration into soils was studied at five sites. Instrumented study plots were established on:

   (a) A peat area at the edge of a lake.

   (b) A 1938 burn planted to ponderosa pine.

   (c) An old-growth western hemlock stand with remnant western white pine and western larch, adjacent to area (b).

(d) A 100-year-old western white pine stand.

(e) A meadow vegetated with native grasses and forbs.

Fiberglass electrical soil moisture units were installed at each site to sample the soil by 3-inch layers. The sites were also equipped with instruments to measure meteorological factors. In addition, ground water wells were established at plots (a), (d), and (e).

Daily measurements of soil moisture, meteorological factors, and ground water were made from early July to mid-November 1952. Field work also included the determination of the bulk density of the soil at each site, infiltration runs, and sampling for the determination of a variety of soil physical constants.

2. Three infiltration study sites near Miles City, Montana were selected and instrumented in preparation for study. Soil moisture units and plot fences were installed on two silt loam soils and one clay soil on the U. S. Range Livestock Experiment Station area in November.

3. A tentative selection was made of study areas in the Palouse region south of Spokane, Washington. The areas selected are silt loam soils under cultivation and under ponderosa pine stands, and an alluvial silty clay loam.

4. A compact and sturdy switching unit was developed for use with soil moisture ohmmeters. A number of suggestions were tested in the field resulting in the development of a system of handling soil unit lead wires and of a switching unit. These developments provide a standard for electrical soil moisture instrument use at this station.

B. Plans for 1953

1. Data collected during 1952 will be analysed and reported.

2. Infiltration on the five 1952 plots will be studied again in the spring of 1953. Lack of rain during the 1952 field season resulted in insufficient data on moist soil. Additional field work from the time snow disappears until late spring of 1953 should fill the gaps.

3. Four or five soil moisture infiltration plots will be established and operated in the Palouse soils. Field observations are expected to begin by mid-summer.

Division of Wildlife Research[1/]

A. Accomplishments in 1952

1. Previous findings that deer significantly damage ponderosa pine reproduction by browsing are being checked and strengthened in two ways: (a) additional deer exclosures have been established on Dunn and Butler Creeks, Kootenai National Forest, by J. Neils Lumber Company, and the station in conjunction with scarification studies. These are being surveyed for effects of deer browsing. (b) Dr. Charles W. Waters, Plant Pathologist, Montana State University, is cooperating in a study of factors in seedling survival other than deer browsing.

2. An important relationship between ponderosa pine seed supply and rodent populations is unfolding. The numbers of mice, chipmunks, and pine squirrels seem to be governed, in part at least, by the availability of pine seed. The rate of seed production varies from year to year. In poor seed years all rodents suffer and populations are low. In moderate seed years, the squirrels, which have first claim to the crop since they harvest the cones, are well fed and numerous, but the mice and chipmunks go hungry. In bumper seed years squirrels, mice, and chipmunks all eat well and are numerous. Thus the population levels of mice and chipmunks are determined by both production of pine seed and consumption of seed by squirrels. In order to determine more specifically the bearing of rodent populations on natural conifer reseeding, two new stations were established for small mammal population studies. These are on Dunn and Butler Creeks, Kootenai National Forest.

   Although field mouse (Microtus) populations are at their cyclic peak in grasslands, they have shown no comparable increase in wooded areas.

3. Studies of food habits of snowshoe hares show that Douglas-fir, creeping hollygrape (Odostemon repens) and ponderosa pine constitute the bulk of the winter diet in the Flathead Lake region. At the year's end population studies are getting under way using islands in Flathead Lake as natural enclosures. On one island a large hare population occurs naturally. Two other islands have no hares. Hares will be introduced on them to study census techniques and population dynamics.

4. A new bibliographic technique using notch-cards is being developed for use in the wildlife field. A report is in rough manuscript form. The technique uses punch-card principles in searching the

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1/ Maintained at the Northern Rocky Mountain Forest & Range Experiment Station by the U. S. Fish and Wildlife Service. The Biologist, Lowell Adams, returned from educational leave at Johns Hopkins University in May and has resumed program activities at the station.

literature. Complete cross-referencing of subject, author, species, and date is made possible with but one set of cards. A card catalogue of the owner's separate files and references to abstracting journals are other automatic features.

B. Plans for 1953

1. Expand the deer exlosure studies to include six new exclosures, and to include research on mortality factors other than browsing.

2. The studies of effects of simulated browsing on conifer reproduction, which have been maintained since 1948, will be reviewed after next spring's survey to decide whether to conclude or continue to the full ten years as originally planned.

3. Continue population and food habits studies of snowshoe hares.

4. Publish the Notch-card Bibliography Technique.

Division of Forest Pathology[2/]

Pole blight is a killing disease affecting many young white pine stands in widely scattered areas. We do not know the cause of the disorder, if it is infectious, or how it is transmitted. The symptoms preceding death, which consist of stunted, yellowish foliage; dwarfing of lateral and terminal shoots; and, in later stages, the development of flat faces with or without resin flow, have been well established. Investigations this year continued in two principal phases--surveys and research. As previously described, pole blight investigations represent an outstanding job of cooperation--specifically the combined efforts of the University of Idaho, the Laboratory of Forest Biology (Canada), the Forest Service, and the Division of Forest Pathology. The following reports the activities of the latter division for 1952.

A. Accomplishments in 1952

Surveys

1. Forty-five new pole blight diseased areas were found in 1952. Of these 21 are in pole stands that formerly had no known blight and 24 are in the vicinity of old blighted areas. There are now about 320 distinct pole blight areas in the commercial range of western white pine which total an estimated 65,000 to 70,000 acres showing moderate to severe damage.

2/ Maintained at the Northern Rocky Mountain Forest and Range Experiment Station by the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Scouting surveys in 1952 were concentrated in pole stands where no blight had been discovered in order to determine whether or not these stands were actually disease-free. Considerable time was spent scouting pole stands on the southern part of the St. Joe National Forest. Several new disease centers were found in large pole stands that had previously been considered free. No pole blight was found farther south than that in Big Sand drainage (Disalto Creek), St. Joe N.F., although new areas were found near this southern limit indicating an intensification to the south. A number of blighted areas were found farther north and east on the Kootenai National Forest, several of which were in young sawtimber.

In comparison with past years, the new areas found during 1952 tended to be, on the average, of more recent origin. A number of infected areas also contained diseased trees over 100 years of age, and from 20 to 30 inches d.b.h. Results of the summer's survey show no indication of a decrease in spread or intensification of the disease.

A few days were spent on initial scouting of pole stands west of the Cascade range. No pole blight was found but the preliminary survey work indicates that the western slopes of the Cascades contain enough white pine pole stands to warrant more complete and intense survey work in the future.

Research

2. Field inoculations with the fungus Leptographium sp. on western white pine over a period of four years have not produced definite and consistent pole blight symptoms. Inoculations on more than 500 trees of various ages generally produced lesions on stems and roots during the first growing season following inoculation. The lesions, or necrotic areas, varied in size and were accompanied by varying degrees of resin flow. During the second and succeeding years, however, these lesions have become callused over or have ceased to enlarge and the associated resin flow has also ceased, perhaps indicating an inability on the part of the fungus to overcome the vigor of the host. This observation is substantiated in part by only partial success in reisolating the fungus from arrested lesions. The inoculations made during 1949, 1950, and 1951 all show the same trend. No other symptoms of pole blight have been produced which can be attributed directly to Leptographium during this short observational period. However, some roots have been killed by it through artificial inoculation.

3. Root mortality study initiated. The principal objectives of this study are to find out what the normal root mortality is in the white pine stands and to find out how affected and probable susceptible stands compare to the normal. The work this year was in the nature of a pilot test in an effort to develop a

satisfactory sampling technique. Since samples were taken from a limited number of areas, no definite conclusions can be drawn from the study. However, preliminary analyses show the following trends: (a) a greater living root length and total number of fine feeding roots in a chosen healthy stand in the unaffected Clearwater area than there is in both an early pole blight stand and a healthy stand in an affected area, and (b) a higher mortality in the fine feeding roots in the latter two areas than there is in the healthy Clearwater area. Whether this difference is due to site, soil, and other environmental factors or to disease can perhaps be established through more extensive sampling to be undertaken in the coming field season.

4. Study of the relation of wood lesions and resinosis to the pole blight complex was completed. In addition to the 22 white pine trees which were dissected and diagrammed in 1951, 31 trees were treated in a similar manner in 1952. The field data from this work have not yet been studied but their analysis will complete the information on the trends established from the 1951 studies which are as follows:

   a. A lack of correlation between the other symptoms of pole blight and the amount of cambial death (lesions) or girdling.

   b. A strong indication that lesions follow or develop after the affected trees start to decline both in radial wood and terminal shoot growth rather than before this reduction.

   c. An indication that lesion activity or expansion takes place during the first year of establishment and may enlarge for a few additional years but at a much reduced rate.

   d. The presence of white or bleached streaks on the wood face which appear to have some important relation to lesions.

   e. A strong suggestion that dead branches or branch stubs are associated with the lesions, particularly the smaller ones.

5. Observations on a tree-topping experiment designed to check the progress of pole blight in individual trees show no apparent change in the progress of the disorder after one year.

6. Mortality due to pole blight has not decreased appreciably on fertilized plots. Plots to which nitrogen (ammonium nitrate) and nitrogen plus calcium and boron had been added have had slightly less mortality than control plots. Plots on which calcium or boron had been added have had slightly more mortality than the checks. Because of the small area and number of trees treated in this

experiment, the trends so far suggested may not be significant. A similar test on a large scale is planned for the near future.

B. Plans for 1953

1. Surveys. Surveys will be concentrated on the Clearwater National Forest and on the western slopes of the Cascades.

2. Research.

   a. Complete wood lesion analyses.

   b. Continue root mortality studies.

   c. Continue observations on inoculated trees.

   d. Establish additional fertilizer studies.

   e. Initiate resistance studies.

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Boe, Kenneth N.
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Division of Forest Management Research
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Forest Genetics Steering Committee
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LeBarron, Russell K.
Silvicultural practices for lodgepole pine in Montana. Station Paper No. 33. July 1952.

Lynch, Donald W.
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Pole Blight Investigations Steering Committee
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Growth of selectively cut ponderosa pine stands in the Upper Columbia Basin. U.S.D.A. Agric. Handbook No. 39. August 1952.

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Watt, Richard F.
Western white pine stands show irregular growth pattern. Research Note No. 113. November 1952.

Wellner, C. A.
A vigor classification for mature western white pine trees in the Inland Empire. Research Note No. 110. May 1952.

Division of Range Research

Evanko, A. B.
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Will beetles lick goatweed? The Washington Farmer LXXVII(12): 16, 17, 20. June 19, 1952. Also: The Idaho Farmer LXX(12): 16, 17, 36. June 19, 1952.

Division of Range Research
Research Hi-Lites. January 1952.
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Reed, M. J.
Kochia rates with alfalfa. Montana Farmer-Stockman. April 15, 1952.

Short, L. R.
New equipment for the 3-step method. Research Note No. 111. August 1952.

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Reseeding to increase the yield of Montana range lands. U.S.D.A. Farmers' Bull. No. 1924. Rev. May 1952.

Woolfolk, E. J.
Making the most of the research dollar. Jour. Range Management, vol. 5, no. 1. January 1952.

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Range conservation is the key. Montana Affairs (Official publication of Montana State Chamber of Commerce). Vol. II, no. 3. April 1952.

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Goatweed beetle doing well. Montana Farmer-Stockman. May 1, 1952.

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Montana range lands. Forestry Kaimin (Montana State University Forestry School). 1952.

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Book review: "Nuttal's travels into the old Northwest." The Scientific Monthly, vol. LXXV, no. 1. July 1952.

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Drought on the plains. Western Livestock Reporter. Sept. 17, 1952.

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Drought emphasizes advantages of conservative stocking. Western Livestock Reporter. October 15, 1952.

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Effects of dry fall on range livestock industry. Western Livestock Reporter. November 19, 1952.

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Range plant problems confront stockmen. Western Livestock Reporter. December 17, 1952.

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Valuation of ponderosa pine stumpage by use of tree grades. Jour. For. Prod. Res. Soc., II(1):90-95. April 1952.

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Pulp mill sites in eastern Montana in relation to effects on water quality of the Upper Missouri and Yellowstone Rivers. Research Hi-Lite. December 1952.

Division of Flood Control Surveys

Helmers, Austin E.
Precipitation measurements on wind-swept slopes. Northwest Science, XXVI(2):65-68. June 1952.

Division of Forest Pathology

Wright, Ernest and Graham, Donald P.
Surveying for pole blight. Jour. Forestry 50(9):680-682. 1952.

PERSONNEL

A most serious blow to the station's program came at mid-year when our Flood Control Survey appropriation was virtually eliminated. Seven of the eight technicians and two clerical personnel were transferred to other Forest Service assignments. One man remains on Flood Control summary activities.

Other personnel changes of significance took place in 1952. The chief of the Division of Forest Management Research was transferred to another experiment station in July. His successor had not been selected at the year's end. One assistant project leader in range research, who had been on educational leave, resigned. At the close of the year the range research project leader in charge of Northern Great Plains range studies accepted a two-year Point IV assignment in Iran. One man transferred out of the forest survey organization. Two new technical men were recruited to fill vacancies created or to staff the new infiltration project. Numerous other adjustments, particularly in the clerical staff, were necessary in 1952.

The station had a total of 40 employees at the close of 1952 compared with 43 a year ago. The roster as of December 31, 1952, follows.

OFFICE OF DIRECTOR

George M. Jemison		Director
Mary J. Pershina		Administrative Assistant
S. Dagmar Nelson		Secretary
Joanne C. Helding		Clerk-Stenographer

DIVISION OF FOREST MANAGEMENT RESEARCH

_____	(Chief)	Forester (For. Man. Res.)
Marie Van Loon		Clerk-Stenographer

DIVISION OF RANGE RESEARCH

E. Joseph Woolfolk	(Chief)	Range Conservationist
Roald A. Peterson		Range Conservationist
Merton J. Reed		Range Conservationist
Katherine E. Lamoreaux		Clerk-Stenographer

DIVISION OF FOREST ECONOMICS

Harry W. Camp, Jr.	(Chief)	Forest Economist
S. Blair Hutchison		Forest Economist
Paul D. Kemp		Forest Economist
Gordon A. Hutton		Forester (Mensuration)
James S. Watson		Forester (Mensuration)
John H. Wikstrom		Forester (Mensuration)
Henry J. Pissot		Forestry Aid (Research)
Harold E. Hanson		Forestry Aid (Research)
Martin E. Reed		Forestry Aid (Research)
Monica E. Hobe		Clerk-Stenographer

DIVISION OF FLOOD CONTROL SURVEYS

Harry W. Camp, Jr.	(Chief)	Forest Economist
C. Allan Friedrich		Forester (For. Inf.)

FOREST UTILIZATION SERVICE

Irvin V. Anderson	(Chief)	Forester
Hilda C. Griffiths		Clerk-Stenographer

DIVISION OF FOREST FIRE RESEARCH

Jack S. Barrows	(Chief)	Forester (Fire Res.)
George R. Fahnestock		Forester (Fire Res.)
Charles E. Hardy		Forester (Fire Res.)
Vincent J. Schaefer		Collaborator
Edna H. Campbell		Clerk-Stenographer

INFILTRATION PROJECT

Austin E. Helmers	(In Charge)	Forester (For. Inf.)
James C. Holland		Soils Scientist (Forestry)
John H. Dieterich		Forestry Aid (Research)

INLAND EMPIRE RESEARCH CENTER

Charles A. Wellner	(Leader)	Forester (Res. Adm.)
Donald W. Lynch		Research Forester (Gen.)
Anthony B. Evanko		Range Conservationist
Marvin W. Foiles		Forester (Silv.)
Richard F. Watt		Forester (Silv.)
Ernest E. Hubert		Collaborator
Vandella I. Gordon		Clerk-Stenographer

UPPER COLUMBIA RESEARCH CENTER

Arthur L. Roe	(Leader)	Forester (Silv.)
Kenneth N. Boe		Forester (Silv.)
Anthony E. Squillace		Forester (Silv.)
Marie Van Loon		Clerk-Stenographer

FIELD STATIONS

Deception Creek	(Coeur d'Alene, Idaho)	Marvin W. Foiles, In Charge
Priest River	(Priest River, Idaho)	Austin E. Helmers, In Charge
Coram	(Coram, Mont.)	Kenneth N. Boe, In Charge
Northern Plains	(Miles City, Mont.)	Laurence R. Short, In Charge
Vigilante	(Alder, Mont.)	Jack E. Schmautz, In Charge

FOREST PATHOLOGY

(In cooperation with Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering):
Charles D. Leaphart, Missoula, Montana.

FOREST WILDLIFE

(In cooperation with Fish and Wildlife Service, Department of Interior):
Lowell Adams, Missoula, Montana.

FOREST INSECT CONTROL

(In cooperation with Bureau of Entomology and Plant Quarantine):
James C. Evenden, Coeur d'Alene, Idaho.

DEPARTMENTAL PUBLICATIONS PLANNED FOR F.Y. 1953

Holscher, C. E. and Woolfolk, E. J.
Proper forage utilization key to efficient cattle production in northern Great Plains. U.S.D.A. Circular. Est. 30 pages.

Moss, Virgil D. and Wellner, Charles A.
Aiding blister rust control by silvicultural measures in the western white pine type. Circular series. Est. 20-30 pages. (To be issued by Bureau Entomology and Plant Quarantine.)

DEPARTMENTAL PUBLICATIONS PLANNED FOR F.Y. 1954

Friedrich, C. A. and Woolfolk, E. J.
Reseeding formerly plowed range lands in central Montana. U.S.D.A. Circular. Est. 30-40 pages.

Reed, M. J. and Peterson, R. A.
Response of cattle and range to stocking rate in the northern Great Plains. U.S.D.A. Technical Bulletin. Est. 50-60 pages.

OTHER PUBLICATIONS PLANNED FOR RELEASE IN CALENDAR YEAR 1953

Division of Forest Economics

Camp, H. W., Jr. et al
Production of wood products in the northern Rocky Mountain region, 1952. Station Paper.

Hutchison, S. Blair, et al
Impact of the proposed Libby Dam upon Lincoln County. An office report.

Jemison, George M.
The forest survey -- a basis for sound forest land development. Proc. Industrial Research and Development.

Kemp, P. D. and Pissot, H. J.
Forest statistics for North Idaho. Station Paper.

Wikstrom, J. H.
Christmas tree shipments in 1952. Research Note.

Wikstrom, J. H. and Kemp, P. D.
A test survey in Southeast Idaho. Research Note.

Division of Forest Management

Barnes, Burton V.
Results of thinning ponderosa pine in western Montana. Research Note.

Bingham, R. T., Squillace, A. E. and Duffield, J. W.
Breeding blister rust resistant western white pine. Journal of Forestry.

Boe, Kenneth N.
Twenty years' growth following three methods of cutting tests in ponderosa pine. Research Note.

Boe, Kenneth N.
Western larch and Douglas-fir seed dissemination from a specific seed source. Research Note.

Boe, Kenneth N. and Squillace, A. E.
Natural regeneration following seed tree cuttings in western larch--Douglas-fir type. Research Note.

Foiles, Marvin W.
Effects of thinning a 55-year-old western white pine stand. Northwest Science.

Foiles, Marvin W.
Thirty-year results of thinning a 60-year-old western white pine stand. Research Note.

Foiles, Marvin W.
Summary of thinning tests in the western white pine type. Station Paper.

LeBarron, Russell K. and Jemison, George M.
Ecology and silviculture of the Engelmann spruce-alpine fir type. Journal of Forestry.

Lynch, Donald W.
Growth of young ponderosa pine trees in the Inland Empire. Station Paper.

Lynch, Donald W.
Measured growth on six site II ponderosa pine plots. Research Note.

Lynch, Donald W.
Heavy cuts in second-growth ponderosa pine result in excessive logging damage to residual stands. Research Note.

Roe, Arthur L.
Seedbed preparation in western larch--Douglas-fir: Costs and requirements. Research Note or Journal article.

Roe, Arthur L. and Boe, Kenneth N.
Logging costs of light second cut in ponderosa pine. Research Note.

Roe, Arthur L. and Boe, Kenneth N.
Logging costs associated with clearcutting western larch--Douglas-fir in blocks. Research Note or Journal article.

Roe, Arthur L. and Squillace, A. E.
Effect of cutting methods on logging costs in larch--Douglas fir. Journal of Forestry.

Squillace, A. E.
Dispersal of Engelmann spruce seed. Research note.

Squillace, A. E.
Breeding for quality and vigor in western white pine. Research Note.

Squillace, A. E.
Seed weights of intraspecific crosses in white pine correlated with first-year seedling height growth. Proc. Montana Acad. Science.

Watt, Richard F.
Prediction of normality changes in western white pine stands. Station Paper or Journal of Forestry.

Watt, Richard F.
Site index changes disclosed by study of western white pine plot records. Research Note.

Watt, Richard F.
Composition changes in immature western white pine stands. Research Note.

Watt, Richard F.
Mortality in immature western white pine stands. Research Note.

Wellner, Charles A.
Effect of tree vigor on growth and mortality in mature western white pine. Northwest Science.

Williams, Henry J.
Decay following pruning western white pine trees. Research Note.

Division of Range Research

Evanko, A. B.
Forage species for reseeding northeast Washington range lands. Northwest Science.

Evanko, A. B.
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Evanko, A. B.
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Peterson, R. A.
Comparative effects of seed treatment upon seedling emergence in seven browse species. Research Note and Ecology.

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Forage plants in a Montana high altitude nursery. Journal of Range Management, and Station Research Note.

Peterson, R. A.
Effects of intensities and methods of seedbed preparation and seeding methods and species adaptability on establishment of seedling stands at high altitudes. Research Note.

Peterson, R. A.
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Peterson, R. A.
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Peterson, R. A. and Evanko, A. B.
Comparison of protected and grazed mountain ranges in southwestern Montana. Journal of Range Management and Station Research Note.

Peterson, R. A. and Schmautz, J. E.
Effects of sagebrush removal and various land treatments on species establishment and herbage production. Research Note.

Peterson, R. A. and Woolfolk, E. J.
A guide for range reseeding on and near the national forests of Montana. Revision of Station Paper No. 7.

Schmautz, J. E.
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Schmautz, J. E.
Effects of cattle breeding practices on calf crops and calf weights on mountain summer range. Montana Stockgrower and Station Research Note.

Schmautz, J. E. and Evanko, A. B.
Controlling Wyethia on mountain summer ranges. Research Note.

Reed, M. J.
Plant height as an indicator of vigor. Journal of Range Management or Ecology.

Short, L. R.
New Equipment for the 3-step method. Journal of Range Management.

Short, L. R. and Reed, M. J.
Range condition reflected by plant heights. Journal of Range Management, and Station Research Note.

Woolfolk, E. J.
Range Research. Twelve contributions to the Western Livestock Reporter.

Woolfolk, E. J. and Short, L. R.
Renovating old stands of crested wheatgrass. Montana Farmer-Stockman, and Station Research Note.

Range Research Staff
Research Hi-Lites. Six issues.

Division of Fire Research

Barrows, J. S.
Fire research in northern Rocky Mountain forests. Station Paper.

Barrows, J. S. and Schaefer, Vincent J.
The jet stream and forest fire control. Fire Control Notes.

Fahnestock, George R.
Preliminary findings on the rate of spread of fire in logging slash. Research Note.

Fahnestock, George R. and Harris, Herbert K.
Airplane vs. lookout in forest fire detection. Fire Control Notes.

Fahnestock, George R. and Olson, D. S.
Task force slash. Either as Station Paper or University of Idaho bulletin.

Hardy, Charles E.
Inflammability ratings for flash fuels. Research Note.

Hardy, Charles E.
Manufacture of fuel moisture indicator sticks. Station Paper.

Hardy, Charles E.
Fire danger rating techniques. Station Paper.

Infiltration Project

Helmers, Austin E.
Precipitation measurements on windy slopes. American Geophysical Union Transactions.

Helmers, Austin E.
Comparision of snow water content and rain gauge catch. Proc. Western Snow Conference.

Helmers, Austin E.
Hygrothermograph adapted to record wind velocity also. Journal of Forestry.

Holland, James C.
Comparative infiltration rates of a forested and cut-over tract in northern Idaho. Research Note.

Division of Wildlife Research

Adams, Lowell
A notch-card bibliographic file for vertebrate ecology. Ecology.